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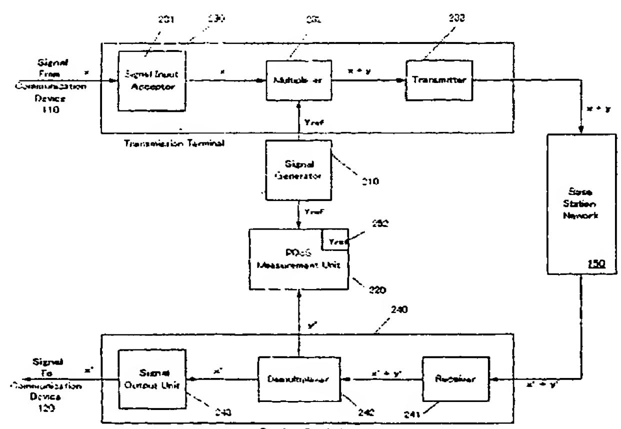

(57) Abstract: This invention provides a system and method for measuring the perceptual quality of service (PQoS) of a signal transmitted in a communications network. A predetermined reference signal is embedded into a signal transmitted from a communications device in the communications network. The transmitted signal is intercepted and the predetermined reference signal is embedded onto the transmitted signal prior to it being received by the telecommunications network, e.g., by multiplexing. The composite signal, which comprises the predetermined reference signal embedded onto the transmitted signal is received by the telecommunications network. The composite signal travels through the telecommunications network and is transmitted to another communications device in the communications network. The composite signal is intercepted prior to being received by the other communications device. The composite signal received from the telecommunications network is de-embedded and the transmitted signal and the embedded signal are separated. The transmitted signal is transmitted to the other communications device. The separated embedded signal is forwarded to a PQoS measurement unit which compares the separated embedded signal and the predetermined reference signal to determine the PQoS of the transmitted signal.

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DESCRIPTION

SPECIAL SIGNALING FOR PERCEPTUAL QoS MEASUREMENT

(Technical Field)

The present invention generally relates to measuring perceptual quality of service (PQoS) in a communications network. More particularly, the present invention relates to measuring PQoS using a predetermined reference signal embedded within a signal transmitted through a communications network.

(Background Art)

There are two ways of obtaining a good quality of service within a communications network. One is to design a network which provides measurable, consistent and predictable QoS, *i.e.*, a perfect network. The other method is to continuously monitor and measure the QoS in the network to maintain the required QoS through active control, which, of course, is the realistic approach to this problem.

Since the consumer's perception of the service provided is quite important, measurement of QoS is an integral part of a telecommunication service. As is understood to one skilled in the art, there are two

aspects to QoS: statistical and perceptive. Statistical QoS addresses issues such as availability of service, which is a more objective measurement of resource capabilities and is not pertinent to the present invention. Perceptual QoS (PQoS), on the other hand, attempts to quantify or define the customer's view of how good the service is, which, of course, is a relatively subjective measurement.

In telephony the statistical QoS is measured as the percentage of time an attempted telephone connection is successful. A 95% - 99% availability, for example, is a normal measure of a good QoS. On the other hand, the PQoS measure has been traditionally made through a human subjective test. The result of the human subjective test, known as mean opinion score (MOS), is a conventional way of determining how good a telephony system is from a customer's point of view.

PQoS in a complex network is a sum of the effects of the various components therein on each other and in combination. In view of the diverse interrelationships between the diverse component parts, it is very difficult to calculate and combine measurements of QoS for discrete individual parts. However, a measure of both the statistical and perceptual QoS are desirable

both for service providers and customers for a number of reasons, such as service management and control, service differentiation, churn avoidance, priority and billing systems, maintaining service level agreements or SLAs, and network design and optimization.

There are a number of software tools which maybe used to find MOS from recorded voice samples. For example, Applicant's Voice QoS (DualVQ) may be used to measure PQoS for a voice transmission while the network is off-line and not in service. Additionally, general techniques to measure MOS are described in various International Telecommunication Union (ITU) recommendations, e.g., P.800, P.830, G.107, P.56, P.861 and P.561.

Japanese Patent Application No. 2000-113704, for example, generally describes the transmission of known multimedia clips over a network and measuring the received PQoS for multimedia signal. As will be discussed in more detail hereinafter, PQoS measurements done in this fashion, *i.e.*, comparison of input and output, require a full copy of the transmitted signal, which may be impossible in many situations.

There does not currently exist, however, a reliable means to measure PQoS accurately while a

network is in service. It should, nonetheless, be readily understood that it is important for a network operator to regularly monitor PQoS, thereby ensuring that the customers are receiving a quality service. This is even more important for telephone services which are provided over the Internet, namely voice over Internet protocol (VoIP), and voice over wireless such as a mobile phone, since the quality of these services changes over time even during a telephone call. PQoS is especially important in wireless telephony because dynamic network management may be enhanced with the knowledge of the PQoS in real time. Thus, it would be desirable to constantly measure and monitor the PQoS non-intrusively during a telephone conversation in a real-time and in service communications network, to maintain an acceptable level of quality, as perceived by the users of that network.

It is, therefore, an object of the present invention to provide an improved system and methodology for quantifying PQoS distortions that occur within a communication system, thereby providing a measure by which to improve the PQoS therein.

It is a further object that the system and methodology of the present invention measure network

PQoS substantially in real time, while the network is in service, and non-intrusively.

It is another object of the present invention that the system and methodology of the present invention improve PQoS measurement in a variety of telecommunications, communications applications, and broadcasting networks, e.g., VoIP, mobile telephony, wireless telephony and VoIP over Wireless (VoIPoW), media streaming, TV, and multimedia/multi-service networks

(Disclosure of Invention)

The present invention is directed to a system and method for measuring the perceptual quality of service (PQoS) of a signal transmitted in a communications network. A predetermined reference signal is embedded into a signal transmitted from a communications device in the communications network. The transmitted signal is intercepted and the predetermined reference signal is embedded onto the transmitted signal prior to being received by the telecommunications, e.g., by multiplexing. The composite signal, which comprises the predetermined reference signal embedded onto the transmitted signal is received by the

telecommunications network. The composite signal travels through the telecommunications network and is transmitted to another communications device in the communications network. The composite signal is intercepted prior to being received by the other communications device. The composite signal received from the telecommunications is demultiplexed and the transmitted signal and the embedded signal are separated. The transmitted signal is transmitted to the other communications device. The separated embedded signal is forwarded to a PQoS measurement unit which compares the separated embedded signal and the predetermined reference signal to determine the PQoS of the transmitted signal.

(Brief Description of Drawings)

The objects, features and advantages of the present invention are readily apparent from the detailed description of the preferred embodiments set forth below, in conjunction with the accompanying Drawings in which:

FIGURE 1 is a block diagram illustrating a representative communications network within which the principles of the present invention may be employed;

FIGURE 2 is a block diagram illustrating components used in an apparatus of the present invention; and

FIGURE 3 is a block diagram illustrating various components of the PQoS measurement unit.

(Best Mode for Carrying Out the Invention)

The numerous innovative teachings of the present application will be described with particular reference to the presently preferred exemplary embodiments. However, it should be understood that this class of embodiments provides only a few examples of the many advantageous uses of the innovative teachings herein. In general, statements made in the specification of the present application do not necessarily delimit any of the various claimed inventions. Moreover, some statements may apply to some inventive features but not to others.

With reference now to FIGURE 1 of the Drawings, an exemplary communication network wherein the present invention may be utilized is illustrated. It should, however, be well understood to those skilled in the art, that the process of perceptual quality of service (PQoS) measurement is equally applicable to a variety

of voice communications over a public telephony network, for example, a VoIP network, and mobile phone network, as discussed hereinabove, as well as other wireline and wireless communications. Furthermore, it should also be understood that PQoS measurements and systems are also applicable to any audio, video or data transmission over any communications network and any broadcasting network where measurement of PQoS may be desired.

With reference again to FIGURE 1, there is illustrated a communications network generally designated by the reference numeral 100. In such network, a first communications device 110, which is linked either by wireline or wireless to a telecommunications network, generally designated by the reference numeral 150, communicates therethrough to a second communications device 120. The first communications device 110, for example, a mobile telephone as illustrated or a landline device, transmits a signal, generally designated by the reference numeral 115 and containing a sequence of bits of information therein designated by x, that is received by the telecommunications network 150, which, in turn, transmits a forwarding signal, generally

designated by the reference numeral 125, to the second communications device 120. As is known in the art, the number of communications devices linked to a given telecommunications network node, such as a telecommunications, is only limited by the configuration of the telecommunications network. Thus, a plurality of communications devices may be linked to the aforedescribed telecommunications network 150. Furthermore, communications device 110 may generally communicate with any of a plurality of communications devices linked to telecommunications network 150.

In a preferred embodiment for practicing the principles of the present invention, communications network 100 is a wireless mobile communications network, and communications device 110 is a wireless mobile telephone that transmits signal 115, which corresponds to a voice transmission, and which upon receipt by a base station or other land-line system component becomes distorted by the passage through the telecommunications network, such as generally represented by the telecommunications network 150, to the destination device 120. In another presently preferred embodiment, communications network 100 is a video-telephone communications network, and

communications device 110 could be any device that transmits a multimedia signal that corresponds to video and audio transmissions. Thus, what type of devices communications device 110 and communications device 120 are depend on the type of network communication network 100. The principles of the present invention, as set forth in more detail hereinbelow, address these and other telephonic and telecommunications scenarios.

As is known in the art, telecommunications network 150 in the preferred embodiments of the present invention include a number of receivers, transmitters, servers, and other known components, which enable the communications network 100 to receive and transmit signals from/to the diverse communications devices linked thereto. These and other various components or nodes through which the signal traverses have the potential to distort or otherwise degrade the original signal content, *e.g.*, decrease the signal-to-noise ratio. It should also be understood that the distortions or errors introduced into the signal propagate and combine with other, later distortions in the network.

According to conventional techniques, to measure the PQoS in real time and while the communications

network 100 is in service and in real time, signal 115, *i.e.*, the information designated by x, transmitted from communications device 110 to the telecommunications network 150 is compared to the signal 125 transmitted from the telecommunications network 150 to communications device 120, which should correspond to the same informational content, *i.e.*, x. In other words, the input to the telecommunications network 150 is compared to the output therefrom.

In case of in-service measurement, signal 115 is not available at the receiver in order that a PQoS measurement may be made by comparing it with 125. For this and other reasons, another approach is necessary to efficiently measure and quantize PQoS within an operating system substantially in real time.

The present invention overcomes the aforementioned problems by intercepting the transmitted signal 115 at a first node within the telecommunications network 150, e.g., at first node 155, and there embedding within the transmitter signal 115 a predetermined reference signal, designated in FIGURE 1 by the information y. It should be understood that first node 155 represents the initial point within the telecommunications network 150 before the PQoS is affected and measurement begins and

could represent any initial node after a PQoS measure is desired, e.g., at the communications device 110, at node 155 or any of a number of intermediate nodal components to the terminal node for the analysis.

A composite signal 115', having information content designated by (x + y), then passes through a number of components or nodes within the telecommunications network 150 until reaching a second or terminal node 160. Similarly, a composite signal 125' received at the second node 160 within the telecommunications network 150 is, upon receipt, separated into the component parts, *i.e.*, the embedded predetermined reference signal y and the original transmitted signal 115, both of which due to potential distortion during internodal traversal are designated by the reference identifiers y' and x', respectively, and transmitted as a signal 125 to the communications device 120.

Instead of comparing the information in signals 115 and 125, *i.e.*, the x information, to each other to ascertain PQoS, as done in prior art methodologies, the present invention measures PQoS by the predetermined reference signal y embedded within the transmitted signal 115 x. The reference signal is monitored and

compared at reception (y') with a corresponding value generated or stored locally, e.g., a base or reference information value, y_{ref}. The less distortion between the two signals, *i.e.*, y' and y_{ref}, corresponds to a higher level of PQoS.

With reference now to FIGURE 2 of the Drawings, there are illustrated various components employed in a preferred embodiment of the present invention. A transmission terminal, generally designated by the reference numeral 230, intercepts the aforedescribed signal 115 transmitted from the aforementioned communications device 110, e.g., at first node 155 in a preferred embodiment of the present invention. As illustrated, transmission terminal 230 includes a signal input acceptor 231, which receives the signal 115 (information x), a multiplexer 232, and a transmitter 233 therein. As discussed, the signal input acceptor 231 is configured to intercept the signal 115 transmitted from the communications device 110 before the signal 115 is received at the telecommunications network 150, *i.e.*, received at the initial point of PQoS analysis, e.g., first node 155. It should be understood to one skilled in the art that the signal input acceptor 231 may be configured to only

receive specific signals from specific communications devices. Multiplexer 232 receives the signal 115 from signal input acceptor 231, as shown in FIGURE 2, embeds therein a predetermined reference signal, e.g., a constant or known reference value as received from a signal generator 210, into the transmitted signal, and produces a composite signal, *i.e.*, x + y, which then traverses the telecommunications network 150.

Embedment may be carried out in several different ways. It may be done by time multiplexing (TDM), signal multiplexing (such as watermarking), codemultiplexing, frequency multiplexing, and so on. As an example of time multiplexing, in a circuit-switched network embodiment, the predetermined reference signal y may be embedded into the transmitted signal x at the multiplexer 232 by simply switching between the intended transmitted signal and the predetermined reference signal y to be embedded at predetermined times and for a predetermined duration. In a packet-switched network embodiment, however, a predetermined reference signal y may be embedded into the transmitted signal x by packaging the data to be embedded in a packet and streaming it in the sequence of the packets which represent the desired information. Alternatively,

in the packet-switched network embodiment, a predetermined reference signal y may be embedded into the transmitted signal x before the information is packetized. In this way, both the original x and the embedded predetermined reference signals y will exist within the same packet.

Instead of embedding predetermined but somewhat variable signals into the data stream to provide the requisite comparative information, signals that are already known by both the sender and the receiver may be used instead, e.g., a system constant. An exemplary such system constant includes pilot symbols, which are standard synchronization bits transmitted in a mobile communications network between a telecommunications and a mobile communications device to facilitate linkage therebetween. In this case, the predetermined reference signal of a fixed number of pilot symbols or bit patterns y are embedded into the transmitted signal x, as described hereinabove.

With reference again to FIGURE 2, transmitter 233 receives the composite signal (x + y) from multiplexer 232 and forwards the composite signal within the telecommunications network 150, *i.e.*, the first node 155 transmits the composite signal to other nodes

within the telecommunications network 150 routed to the second node 160. It should be understood to those skilled in the art that the transmitter 233 may be configured to only interface with a predetermined telecommunications network.

As further shown in FIGURE 2, telecommunications network 150 receives the composite signal (x + y) from the original communication device 110. A receiver terminal, generally designated by the reference numeral 240, is in communication with or configured within the telecommunications network 150, and intercepts the composite signal (x + y) before transmission to the communications device 120, e.g., at the aforementioned second node 160. As discussed, due to distortion effects during the transmission and signal traversal through the telecommunications network 150, the signal 125' received at the second node 160 may contain a distorted originally transmitted signal, designated by the reference identifier x'. Likewise for embedded signal y'. Thus, due to potential distortions the composite signal upon receipt at the second node 160 is represented by x' + y'. As illustrated, receiver terminal 240 includes a receiver 241, which receives the composite signal (x' + y'), a demultiplexer 242,

and a signal output unit 243 therein. As discussed, receiver 241 receives the composite signal (x' + y') from the first node 155 and any intermediate nodes within the telecommunications network 150, and may be configured to only receive a predetermined reference signal from a predetermined telecommunications network.

Demultiplexer 242 receives the composite signal (x' + y') from the receiver 241 and separates the composite signal into the constituent parts, *i.e.*, the originally transmitted and potentially distorted signal x' and the predetermined and potentially distorted reference signal y'. Signal output unit 243 receives the potentially distorted signal x' from the demultiplexer 242, and transmits the signal 125 to the communications device 120. It should be understood to those skilled in the art that output unit 243 may be configured to only interface with predetermined communications devices.

It should, of course, also be understood that demultiplexer 242 demultiplexes the composite signal (x' + y') to correspond to the same manner in which multiplexer 232 multiplexed the original transmitted signal x and the predetermined reference signal y. For example, in a circuit-switched network,

if the multiplexer 232 embeds the predetermined reference signal y into the transmitted signal x at predetermined intervals for predetermined lengths of time, then the demultiplexer 242 separates the composite signal (x' + y') at those same predetermined intervals for the same predetermined lengths of time to produce the transmitted signal x' and the separated embedded signal y'.

Similarly, in a packet-switched network, if the multiplexer 232 divides the original transmitted signal x and the predetermined reference signal y into a number of discrete pieces of predetermined length, and prepares a packet sequence where each packet includes one or more pieces of the transmitted signal x and the predetermined reference signal y, then the demultiplexer 242 separates the composite signal (x' + y') in each packet to produce the transmitted signal x' and the separated embedded signal y'. Alternatively, if the multiplexer 232 aligns the packets of the transmitted signal x and the packets of the predetermined reference signal y in a predetermined order, then the demultiplexer 242 separates the composite signal (x' + y') in that same predetermined

order to produce the transmitted signal x' and the separated embedded signal y'.

With reference again to FIGURE 2 of the Drawings, a PQoS measurement unit 220 receives the predetermined reference signal, designated by the reference identifier y_{ref}, from the aforementioned signal generator 210 and the embedded signal y' from the demultiplexer 242 for comparison. (Signal generator 210 and PQoS measurement unit 220 can be separately located. Furthermore, signal generator 210 can already be stored in PQoS measurement unit 220. Or, alternatively, y_{ref} may be stored in memory 252 within PQoS measurement unit 220.) PQoS measurement unit 220 measures the level of PQoS between the communication device 110 and the telecommunications network 150 (or generally between two nodes) by comparing the predetermined reference signal from signal generator 210 (y_{ref}) with the embedded signal received from demultiplexer 242 y'. A comparator and adjustor are used to compare and adjust the signals accordingly. A mechanism such as that used in Genista's Dual-VQ tool may then be used to measure the PQoS for the received signal.

Alternatively, pilot symbols which are used for synchronization in fields of mobile communication using

wide band code division multiple access (WCDMA), orthogonal frequency division multiplexing (OFDM) technologies, etc., may be used as the signal embedded into the transmitted signal, *i.e.*, y. In this case, demultiplexer 242 separates the pilot symbols from the transmitted signal. The level of PQoS is then measured based on the comparison of the separated pilot symbols with the original pilot symbols. Where synchronous multiplexing is employed, e.g., embedded signals y having a length of Y milliseconds are inserted every X milliseconds into the transmitted signal x, separation of the composite signal is accomplished by synchronousdemultiplexing, and pilot symbols, correlation or difference between spectral distributions of a bursted embedded symbol y, and a typical audio signal are helpful in thedemultiplexing.

It should be understood that the embedded signal y preferably forms only a small overhead to the original signal x. Further, the transmission of the predetermined reference signal y may occur at regular intervals or pseudo-randomly, provided the receiving node, e.g., the second node 160, is in synchronicity as to the times of arrival of the embedded PQoS measurement signals. It should further be understood

that the principles of the present invention are generally directed to embedding short bursts of a prior-known signal in the communications stream, as described in more detail hereinabove, and subsequently measuring those prior-known signals at an intended node for the purposes of PQoS.

With reference now to FIGURE 3 of the Drawings, there are illustrated various component parts of an exemplary embodiment of the aforementioned PQoS measurement unit 220 shown in FIGURE 2 and described in connection therewith. In particular, PQoS measurement unit 220 includes a first perceptual model unit 310, a second perceptual model unit 320, a difference calculator 330, and a cognitive model unit 340.

As illustrated in FIGURE 3, the first perceptual model unit 310 receives the predetermined reference signal, *i.e.*, y_{ref}, from a reference signal source, e.g., a memory 252 as illustrated in FIGURE 2, a signal generator 210 as illustrated in FIGURE 2 or other source. As shown and described in connection with FIGURES 2 and 3, the signal generator 210 transmits the same predetermined reference signal to both the multiplexer 232 and the first perceptual model unit 310. It should be understood that in an embodiment where the

PQoS measurement is done in a mobile communications network, pilot symbols may be used instead of embedding a predetermined reference signal into the transmitted signal.

With reference again to FIGURE 3, the second perceptual model unit 320 receives the separated embedded signal, *i.e.*, y', from the demultiplexer 242. First perceptual model unit 310 and second perceptual model unit 320 are converters and convert reference and embedded signals into representation signals that are used to calculate the PQoS over the communications network. It should be understood that the perceptual model units 310 and 320 mimic the function of human sense organs. For example, if the transmitted signal x represents an audio signal, which corresponds to a voice or music data transmission, the first perceptual model unit 310 and the second perceptual model unit 320 mimic the human ears. Similarly, if the transmitted signal x is a video signal, both the first perceptual model unit 310 and the second perceptual model unit 320 are configured to mimic the human eyes. Additionally, if the transmitter signal x is a multimedia signal including both audio and video data transmissions, the first perceptual model unit 310 and the second

perceptual model unit 320 mimic both the human eyes and ears.

It should be understood that a variety of properties may be employed to facilitate this mimicry, e.g., threshold characteristics of audio and visual acuity, utilization of silent periods, etc., and applied to the perceptual model units 310 and 320. With speech or audio, the techniques of the present invention allow objective measurements of the PQoS, e.g., Perceptual Speech Quality Measure (PSQM), speech lulls, speech delay variation (e.g. jitter), and speech level modulation.

With further reference to the PQoS measurement unit 220 illustrated in FIGURE 3, the difference calculator 330 receives the representative signals from both perceptual model units 310 and 320, and calculates the difference between the two representative signals. Difference calculator 330 generates a difference signal corresponding to the degree of difference between the two representative signals. Subject properties applicable in this analysis include listening level, ambient noises around a sender, transmission and reception characteristics, and other factors as are understood in the art.

Cognitive model unit 340 receives the difference signal from the difference calculator 330. It should be understood that the cognitive model 340 may be configured to analyze the difference signal with respect to certain subject properties to measure the quality of the separated embedded signal when compared to the predetermined reference signal. For example, the quality of the separated embedded signal y' as received when compared with the predetermined reference signal, *i.e.*, y_{ref}, corresponds to the quality of service of the transmitted signal x received by the communications device 120, as discussed hereinabove.

It should, of course, be readily understood that the objectives of the present invention may be accomplished utilizing some components known in the art. Furthermore, the objectives of the present invention may be accomplished by the operation of computerized system components implementable in hardware or software or in combination. Accordingly, a computer memory for storing a program for realizing the objects of the present invention, e.g., on a server or other computer may incorporate the subject matter of the present invention thereon.

It should also be understood that the principles of the present invention are applicable between any two nodes within a network. For example, if a caller connects to a telephone exchange node in Osaka to call a friend, who is connected to a telephone exchange node in Nagoya, the PQoS measurement and transmission of embedded signals may only occur between these telephone exchange nodes. Accordingly, the network itself may automatically embed the necessary signal in a multimedia stream therebetween with the knowledge of the parties.

It should further be understood that signal distortion is not the only type of PQoS measurement that is possible employing the subject matter of the present invention. For example, delay jitter in a network may be detected, particularly, in VoIP networks. Since the time interval between two embedded bursts is known to the receiving node, e.g., burst n arrives at t = 10.005 seconds and burst n + 1 arrives at t = 10.020 seconds, any shift in the time difference can be readily detected by the receiver, providing a PQoS measure of network delay jitter.

It should also be understood that in addition to synchronous multiplexing and de-multiplexing, the

embedded signal y may be inserted into the transmitted signal x pseudo-randomly, e.g., using a pseudo-random number generator. For example, sections or pieces of the embedded signal y having a mean length of A milliseconds with a standard deviation of B milliseconds are inserted into the transmitted signal x at intervals with a mean of C milliseconds with a standard deviation of D milliseconds. The receiver demultiplexer 242, however, employs the same random number or pattern generator, e.g., signal generator 210, and can therefore regenerate the same embedding characteristics. Accordingly, receiver terminal 240 (shown in FIGURE 2) can separate the target embedded signal y from the received composite signal x + y synchronously using the local pseudo-random pattern generator, as well as the correlation or difference between spectral distributions of the bursted embedded signal y and a typical audio signal.

The foregoing description of the present invention provides illustration and description, but is not intended to be exhaustive or to limit the invention to the precise one disclosed. Modifications and variations are possible consistent with the above teachings or may be acquired from practice of the

invention. Thus, it is noted that the scope of the invention is defined by the claims and their equivalents.

The present application claims priority on a provisional application, U.S. Serial No. 60/245,109, entitled "System and Method for Closed Loop QOS Measurement", filed on November 1, 2000, which is incorporated by reference herein.

(Industrial Applicability)

This invention is applied generally to communications networks, and more specifically to methods and apparatus for measuring perceptual quality of service (PQoS) in a communications network by using a predetermined reference signal embedded within a signal transmitted through the communications network.

CLAIMS

1. A system for measuring the quality of a transmitted signal from a first communications device to a second communications device transmitted through a communications network, said system comprising:

(a) a transmitter terminal in communication with said communications network, said transmitter terminal comprising:

(1) an input signal acceptor for accepting the transmitted signal from the first communications device;

(2) a multiplexer, connected to the input signal acceptor, for combining a predetermined reference signal with the transmitted signal, forming a composite signal; and

(3) a transmitter, connected to the multiplexer, for transmitting the composite signal to the communications network;

(b) a receiver terminal in communication with said communications network, said receiver terminal comprising:

(1) a receiver receiving the composite signal from the communications network;

(2) a demultiplexer, connected to the receiver, for separating the composite signal received from the receiver into a separated embedded signal corresponding to the embedded predetermined reference signal and a separated transmitted signal corresponding to the transmitted signal; and

(3) an output unit, connected to the demultiplexer, for transmitting the separated transmitted signal received from the demultiplexer to the second communications device; and

(c) a perceptual quality of service (PQoS) measurement unit, connected to receiver terminal, for comparing the separated embedded signal received from the demultiplexer with the predetermined reference signal, whereby the comparison indicates the PQoS associated with the separated transmitted signal received by the second communications device after passing through said communications network.

2. The system according to claim 1, wherein the Perceptual QoS measurement unit further comprises:

a first perceptual model unit, said first perceptual model unit converting the predetermined reference signal into a first representation signal;

a second perceptual model unit, said second perceptual model unit converting the separated embedded signal into a second representation signal;

a difference calculator, in communication with said first and second perceptual model units, for comparing the first representation signal and the second representation signal, and generating therefrom a difference signal, said difference signal based upon the difference between the first representation signal and the second representation signal; and

a cognitive model unit, in communication with said difference calculator, said cognitive model unit receiving the difference signal from the difference calculator and determines a PQoS measurement associated with the transmitted signal based upon the difference signal.

3. The system according to claim 2, wherein the first perceptual model unit and the second perceptual model unit mimic human sense organs.

4. The system according to claim 1, wherein the multiplexer embeds the predetermined reference signal into the transmitted signal at predetermined intervals

for predetermined lengths of time, and the demultiplexer separates the composite signal at the predetermined intervals for the predetermined lengths of time to produce the separated transmitted signal and the separated embedded signal.

5. The system according to claim 1, wherein the multiplexer divides the transmitted signal and the predetermined reference signal into a plurality of pieces of predetermined length, and prepares a packet sequence wherein each packet therein includes zero or more pieces of the transmitted signal and the predetermined reference signal, and the demultiplexer separates the composite signal spread across the plurality of packets in said packet sequence packet by packet to produce the separated transmitted signal and the separated embedded signal.

6. The system according to claim 1, wherein the multiplexer aligns packets of the transmitted signal and packets of the predetermined reference signal in a predetermined order, and the demultiplexer separates the composite signal in the predetermined order to

produce the transmitted signal and the separated embedded signal.

7. The system according to claim 1, wherein the transmitted signal is selected from the group consisting of a voice signal, an audio signal and a video signal.

8. The system according to claim 1, wherein the predetermined reference signal comprises pilot symbols.

9. A receiver terminal for measuring the perceptual quality of service (PQoS) of a transmitted signal from a first communications device to a second communications device transmitted through a communications network, said receiver terminal comprising:

a receiver, said receiver receiving a composite signal from the communications network, said composite signal comprising the transmitted signal and a predetermined reference signal, said composite signal being formed prior to transmission through the communications network;

a demultiplexer, connected to the receiver, for separating the composite signal received from the receiver into a separated transmitted signal corresponding to the transmitted signal and a separated embedded signal corresponding to the predetermined reference signal;

an output unit, connected to the demultiplexer, for transmitting the separated transmitted signal to the second communications device; and

a PQoS measurement unit, connected to the demultiplexer, for comparing the separated embedded signal with the predetermined reference signal, whereby the comparison indicates the PQoS associated with the separated transmitted signal received by the second communications device after passing through said communications network.

10. The receiver terminal according to claim 9, wherein the PQoS measurement unit further comprises:

a first perceptual model unit, said first perceptual model unit converting the predetermined reference signal into a first representation signal;

a second perceptual model unit, said second perceptual model unit converting the separated embedded signal into a second representation signal;

a difference calculator, in communication with said first and second perceptual model units, for comparing the first representation signal and the second representation signal, and generating therefrom a difference signal, said difference signal based upon the difference between the first representation signal and the second representation signal; and

a cognitive model unit, in communication with said difference calculator, said cognitive model unit receiving the difference signal from the difference calculator and determining a PQoS measure associated with the transmitted signal based upon the difference signal.

11. The receiver terminal according to claim 10, wherein the first perceptual model unit and the second perceptual model unit mimic human sense organs.

12. The receiver terminal according to claim 9, wherein the predetermined reference signal in the composite signal is embedded into said transmitted

signal in a predetermined order, and wherein the demultiplexer separates the composite signal in said predetermined order to produce the separated transmitted signal and the separated embedded signal.

13. The receiver terminal according to claim 12, wherein said predetermined order comprises embedding said predetermined reference signal at predetermined intervals for predetermined lengths of time into said transmitted signal.

14. The receiver terminal according to claim 9, wherein the transmitted signal and the predetermined reference signal in the composite signal are spread across a plurality of packets in a packet sequence, and wherein the demultiplexer separates the composite signal in said packet sequence packet by packet to produce the separated transmitted signal and the separated embedded signal.

15. The receiver terminal according to claim 9, wherein the transmitted signal is selected from the groups consisting of a voice signal, an audio signal and a video signal.

16. The receiver terminal according to claim 9, wherein the predetermined reference signal comprises pilot symbols.

17. A method for measuring the perceptual quality of service (PQoS) of a transmitted signal from a first communications device to a second communications device transmitted through a communications network, said method comprising the following steps:

multiplexing, at an initial node of said communications network, the transmitted signal with a predetermined reference signal forming a composite signal;

transmitting the composite signal through the communications network;

receiving the composite signal at a terminal node within said communications network;

demultiplexing the received composite signal, separating the received composite signal into a separated transmitted signal corresponding to the transmitted signal and a separated embedded signal corresponding to the embedded predetermined reference signal;

transmitting the separated transmitted signal to the second communications device; and

comparing the separated embedded signal with the predetermined reference signal, whereby the comparison indicates the PQoS associated with the separated transmitted signal received by the second communications device after passing through said communications network.

18. The method according to claim 17, further comprising the steps of:

converting the predetermined reference signal into a first representation signal;

converting the separated embedded signal into a second representation signal;

generating a difference signal based upon the difference between the first representation signal and the second representation signal; and

determining a PQoS measure associated with the transmitted signal based upon the difference signal.

19. The method according to claim 17, further comprising the steps of: embedding the predetermined reference signal into the transmitted

signal at predetermined intervals for predetermined lengths of time; and demultiplexing the composite signal at the predetermined intervals for the predetermined lengths of time to produce the separated transmitted signal and the separated embedded signal.

20. The method according to claim 17, further comprising the steps of:

dividing the transmitted signal and the predetermined reference signal into a plurality of pieces of predetermined length;

preparing a packet sequence wherein each packet therein includes zero or more pieces of the transmitted signal and the predetermined reference signal; and

demultiplexing the composite signal spread across the plurality of packets in said packet sequence packet by packet to produce the separated transmitted signal and the separated embedded signal.

21. The method according to claim 17, wherein the transmitted signal is selected from the group consisting of a voice signal, an audio signal and a video signal.

22. A method for measuring the perceptual quality of service (PQoS) of a transmitted signal from a first communications device to a second communications device transmitted through a communications network, said method comprising the following steps:

receiving a composite signal from the communications network, said composite signal comprising the transmitted signal and a predetermined reference signal, said composite signal being formed prior to transmission through the communications network;

demultiplexing the composite signal into a separated transmitted signal corresponding to the transmitted signal and a separated embedded signal corresponding to the predetermined reference signal;

transmitting the separated transmitted signal to the second communications device; and

comparing the separated embedded signal with the predetermined reference signal, whereby the comparison indicates the PQoS associated with the separated transmitted signal received by the second communications device after passing through said communications network.

23. The method according to claim 22, further comprising the steps of:

converting the predetermined reference signal into a first representation signal;

converting the separated embedded signal into a second representation signal;

generating a difference signal based upon the difference between the first representation signal and the second representation signal; and

determining a PQoS measure associated with the transmitted signal based upon the difference signal.

24. The method according to claim 22, wherein the predetermined reference signal in the composite signal is embedded into said transmitted signal in a predetermined order, and wherein the demultiplexer separates the composite signal in said predetermined order to produce the separated transmitted signal and the separated embedded signal.

25. The method according to claim 24, wherein said predetermined order comprises embedding said predetermined reference signal at predetermined

intervals for predetermined lengths of time into said transmitted signal.

26. The method according to claim 22, wherein the transmitted signal and the predetermined reference signal in the composite signal are spread across a plurality of packets in a packet sequence, and wherein the demultiplexer separates the composite signal in said packet sequence packet by packet to produce the separated transmitted signal and the separated embedded signal.

27. The method according to claim 22, wherein the transmitted signal is selected from the group consisting of a voice signal, an audio signal and a video signal.

28. The method according to claim 22, wherein the predetermined reference signal comprises pilot symbols.

29. A signal measurement unit for measuring perceptual quality of service (PQoS) with a signal within a communication network, said signal measurement unit comprising:

a comparator for comparing an embedded portion of an incoming signal with a reference signal, said incoming signal further comprising a data signal therein, said embedded portion of said incoming signal and said data signal having a perceptual quality of service measure associated therewith; and

an adjuster for adjusting said data signal using said perceptual quality of service measure.

30. The signal measurement unit according to claim 29, wherein said comparator further comprises:

a first converter, which converts said reference signal into a first representation signal;

a second converter, which converts said embedded portion of said incoming signal into a second representation signal.

31. The signal measurement unit according to claim 29, wherein said comparator further comprises:

a difference calculator, which compares said first representation signal and said second representation signal, and generates a difference signal using said first representation signal and said second representation signal.

32. The signal measurement unit according to claim 29, wherein said comparator further comprises:

a cognitive model unit, which receives said difference signal and determines the PQoS of said data signal using said difference signal.

FIG.1

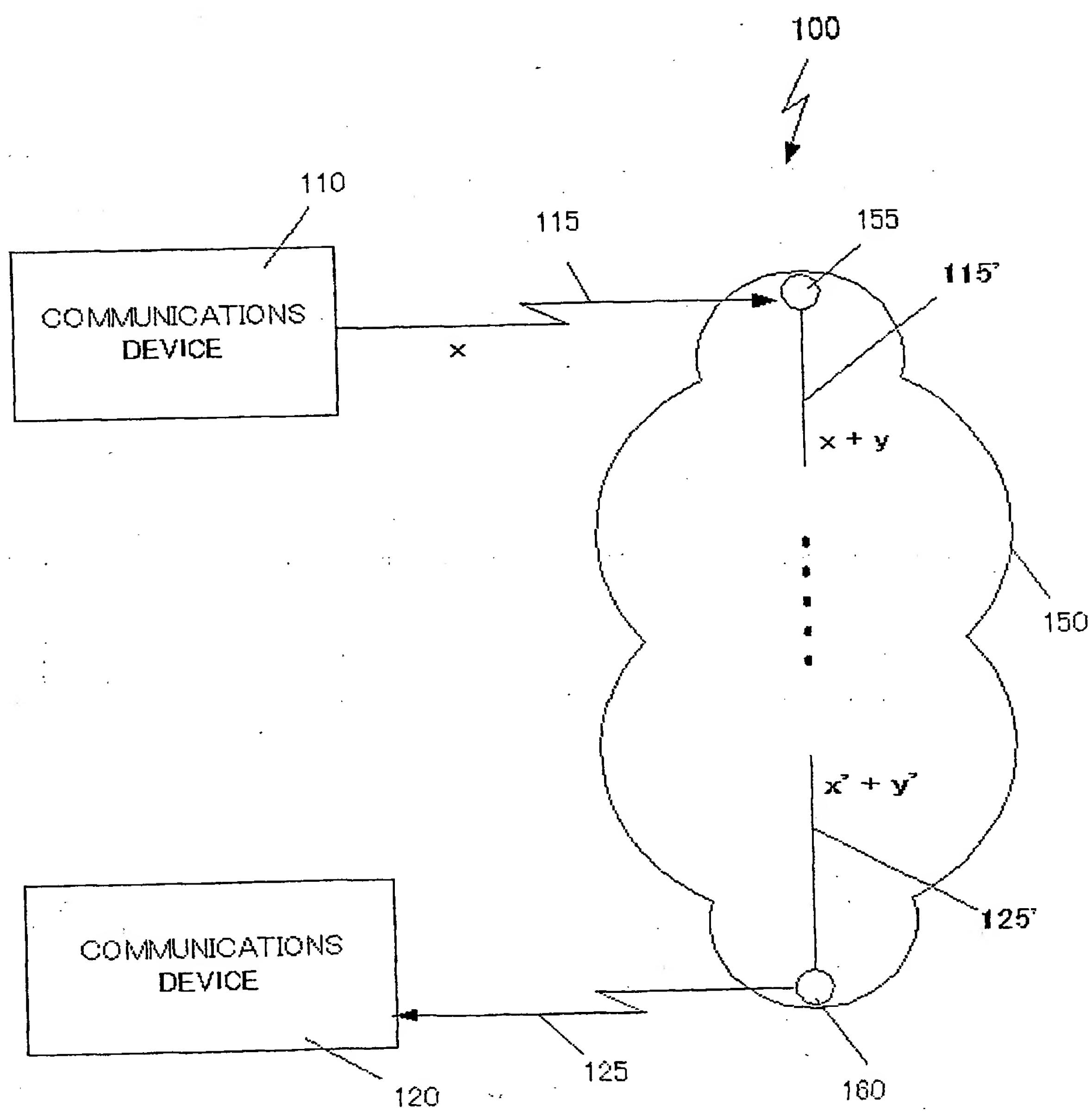
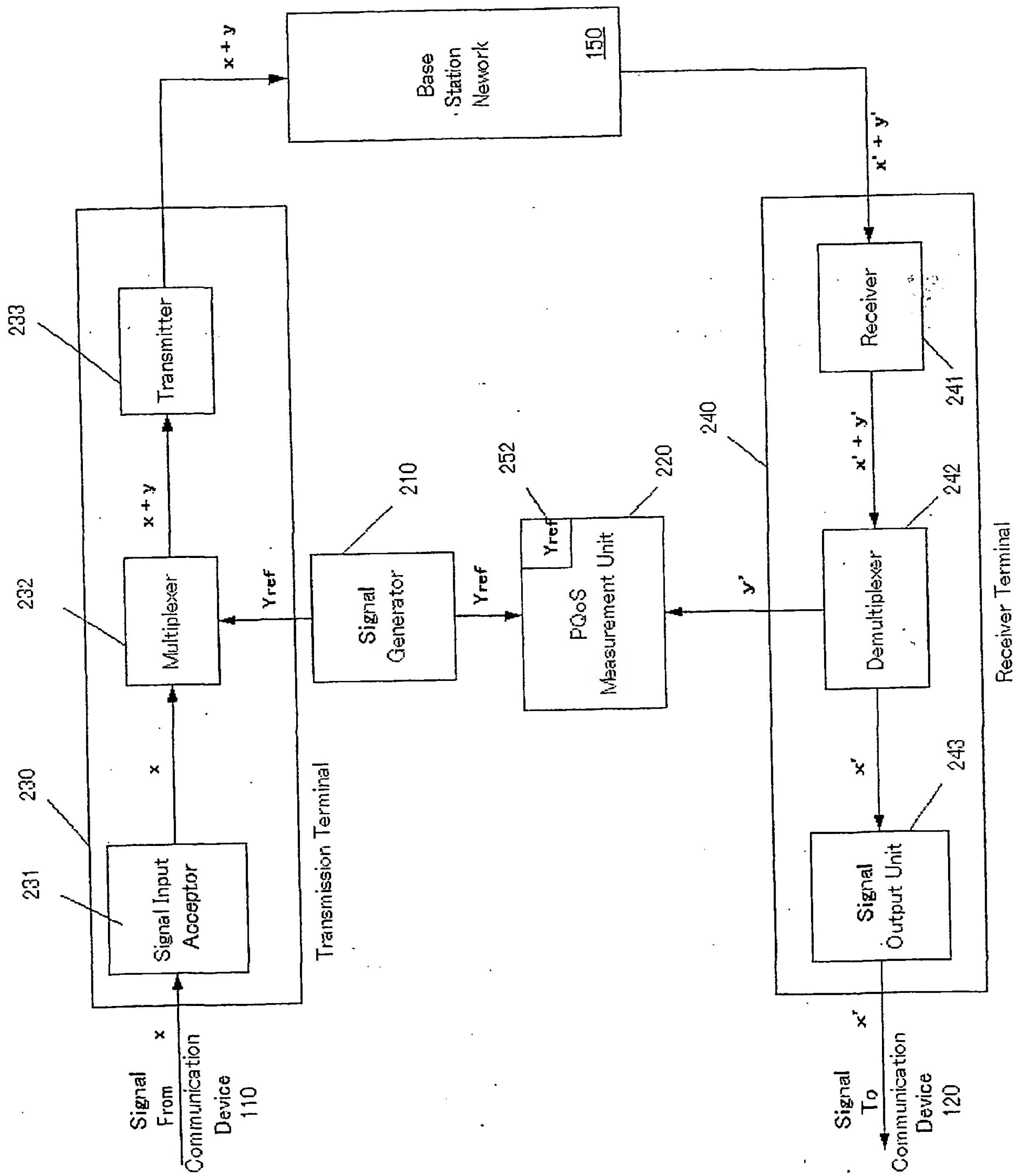
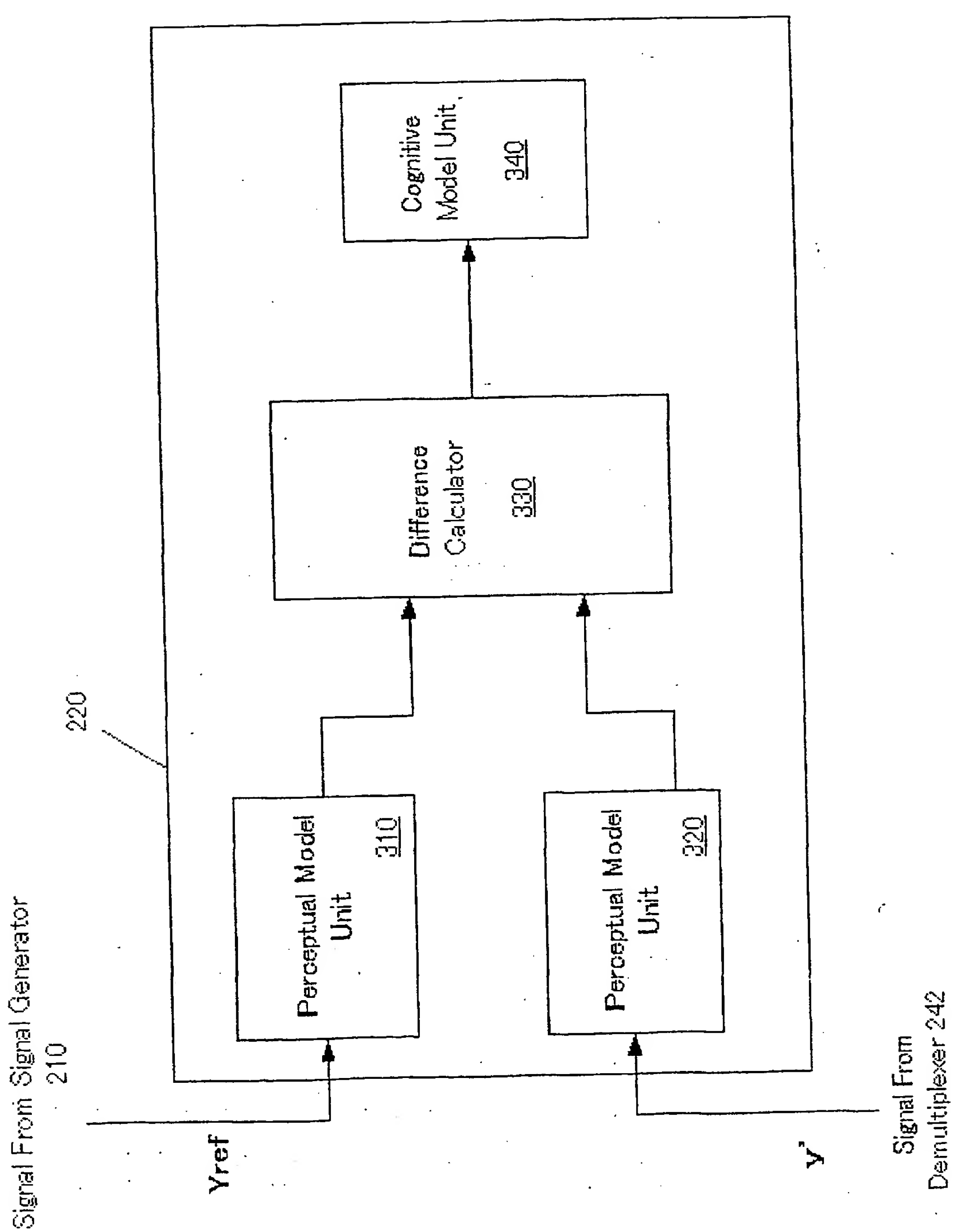

100
110
COMMUNICATIONS DEVICE
115
x
155
115'
x + y
150
x' + y'
125'
COMMUNICATIONS DEVICE
125
120
160

FIG.2



Base Station Nework
150
x + y
x' + y'
Transmitter
233
Multiplexer
232
Signal Input Acceptor
231
230
Transmission Terminal
Signal Generator
210
Yref
PQoS Measurement Unit
220
252
y'
Receiver
241
240
Demultiplexer
242
Signal Output Unit
243
Receiver Terminal
x
x'
Signal From Communication Device 110
Signal To Communication Device 120

FIG.3


Cognitive Model Unit 340
Difference Calculator 330
220
Perceptual Model Unit 310
Perceptual Model Unit 320
Signal From Signal Generator 210
Yref
Y'
Signal From Demultiplexer 242

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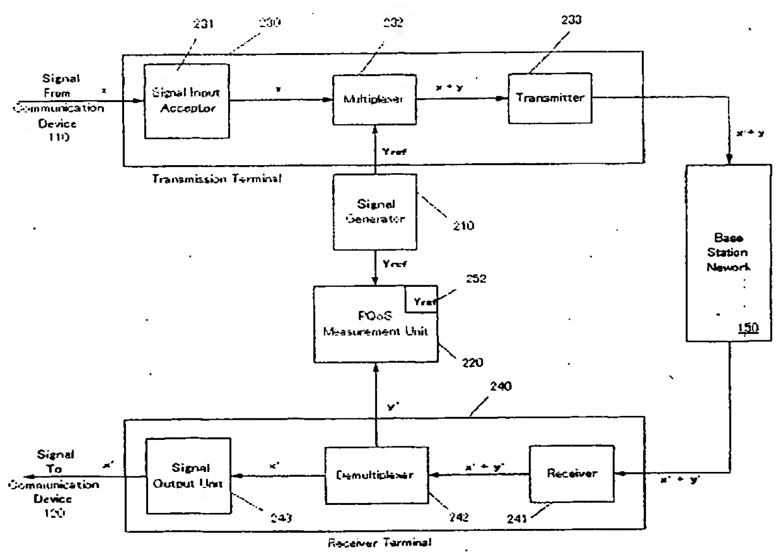
[Continued on next page]

(54) Title: SPECIAL SIGNALING FOR PERCEPTUAL QoS MEASUREMENT



(57) Abstract: This invention provides a system and method for measuring the perceptual quality of service (PQoS) of a signal transmitted in a communications network. A predetermined reference signal is embedded into a signal transmitted from a communications device in the communications network, e.g., by multiplexing. The composite signal travels through the telecommunications network and is transmitted to another communications device in the communications network. The composite signal is intercepted prior to being received by the other communications device. The transmitted signal and the embedded signal are separated. The transmitted signal is transmitted to the other communications device. The separated embedded signal is forwarded to a PQoS measurement unit which compares the separated embedded signal and the predetermined reference signal to determine the PQoS of the transmitted signal.

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04M G10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, COMPENDEX, PAJ

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Giglietto, M

INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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International Application No

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